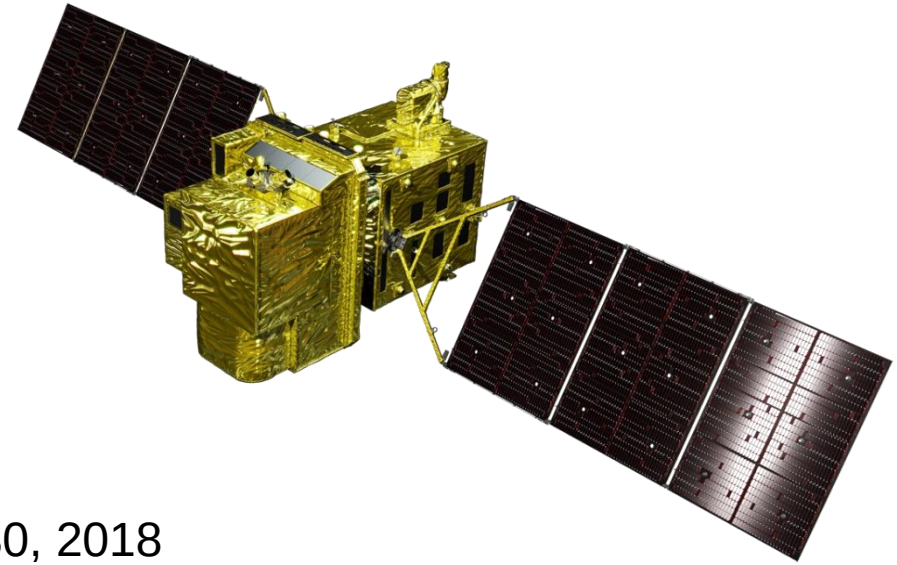
Advanced Optical Satellite (ALOS-3) Overviews



January 30, 2018

Takeo Tadono[1], Hidenori Watarai[1], Ayano Oka[1], Yousei Mizukami[1],
Junichi Takaku[2], Fumi Ohgushi[2], and Masanori Doutsu[2]
[1] JAXA, [2] RESTEC
E-mail: tadono.takeo@jaxa.jp

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ALOS F/O Missions

Continuous observation from “Daichi” (ALOS)

- Contribute to ensure the safety and security of the people, *i.e.* disasters monitoring and management, national developing management, foods and natural resources, environmental issues in global etc. as common issues
- Contribute to industrial development based on Earth observation data *i.e.* National Spatial Data infrastructure (NSDI)

Jan. 2006 — May 2011 — May 2014 — JFY2020 (Target)

Daichi (ALOS)
(Optical & SAR)

Optical: PRISM, AVNIR-2
SAR: PALSAR

ALOS-2 (SAR)

May 24, 2014
SAR: PALSAR-2

- L-band Synthetic Aperture Radar
- Observe in night time and rain
- Wide swath (~490km) and fine resolution (1-3m)

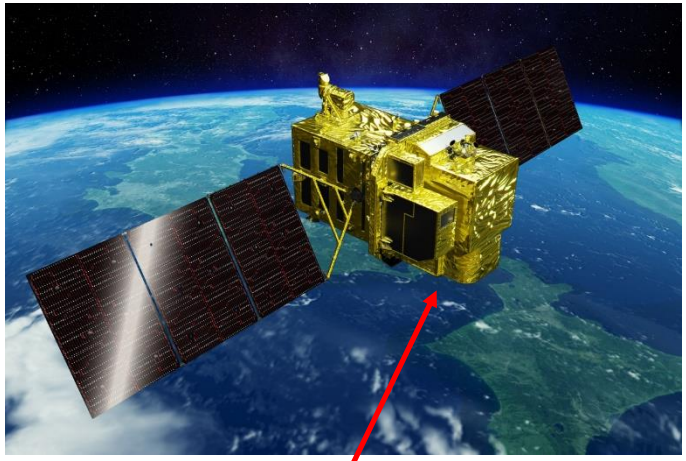
Next Optical

- Panchromatic band : 0.8m
- Multispectral band (6 bands): 3.2m
- Observation swath: 70km at nadir
- Body pointing capability for emergency disaster observation as well as stereo observation

Advanced Optical Satellite (ALOS-3)

Overview of ALOS-3

Items		Specifications
Orbit	Type	Sun-synchronous sub-recurrent
	Altitude	669 km at the equator
	Local Sun Time	10:30 am +/- 15 minutes at the descending node
	Revisit	35 days (Sub-cycle 3 days)
Instruments		- Wide-swath and high-resolution optical imager (WISH, as a tentative) - Dual-frequencies Infrared sensor (hosted payload)
Ground Sampling Distance (GSD)		- Panchromatic band of WISH (Pa): 0.8 m - Multispectral band of WISH (Mu): 3.2 m (6 bands)
Quantization		11 bit / pixel
Swath width		70 km at nadir
Mission data rate		Approx. 4 Gbps (after onboard data compression: 1/4 (Pa) and 1/3 (Mu))
Mission data downlink		- Direct Transmission: Ka and X-band - *via.* the Optical Data Relay Satellite
Mass		Approx. 3 tons at launch
Size		5 m × 16 m × 3.5 m on orbit
Duty		10 mins / recurrent
Design life time		Over 7 years

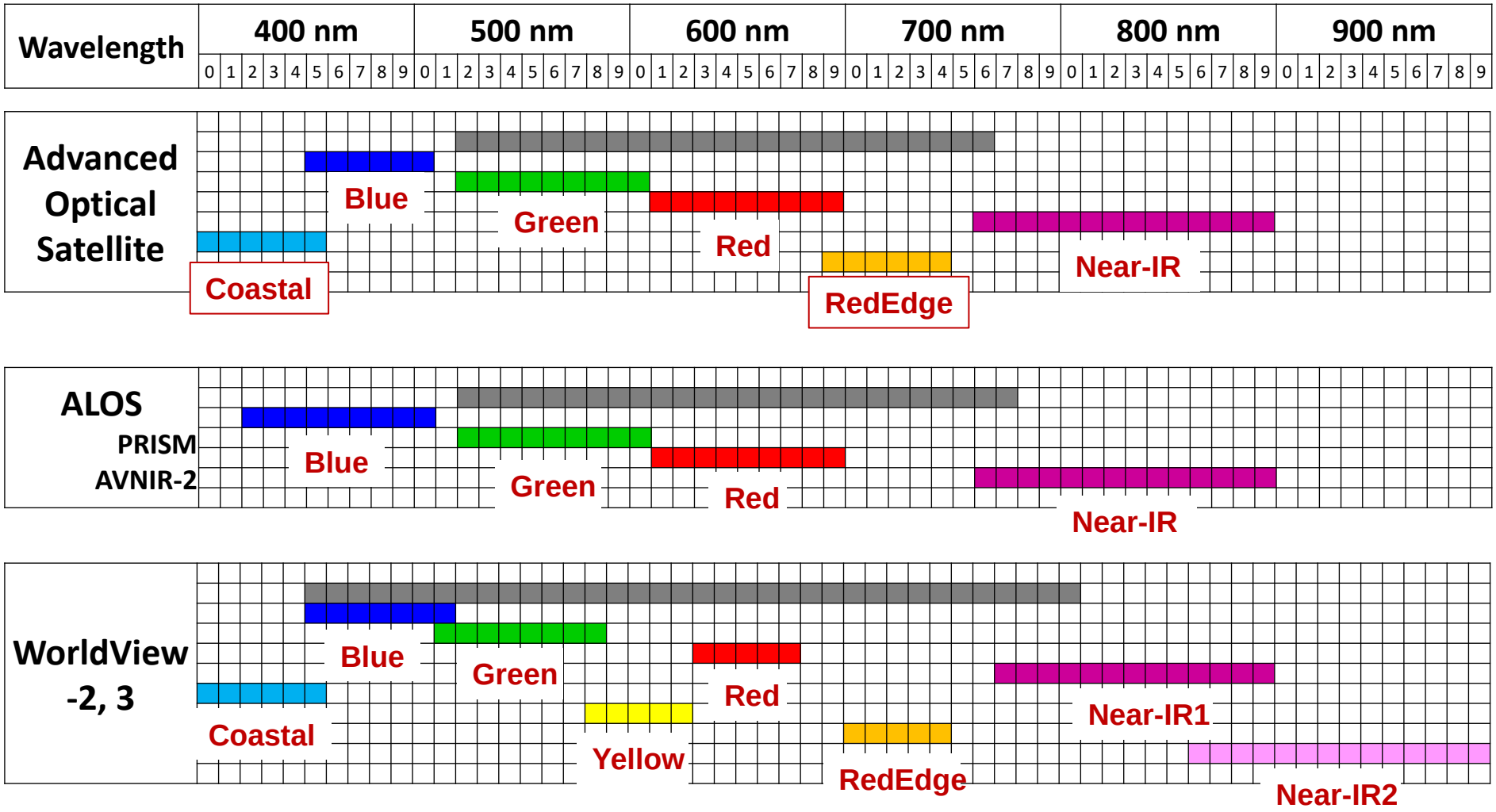


Wide-swath and high-resolution optical imager (WISH)

In-orbit configuration

Wide-Swath and High-Resolution Optical Imager

Observation channel band allocations among optical satellites (visible to near-infrared).

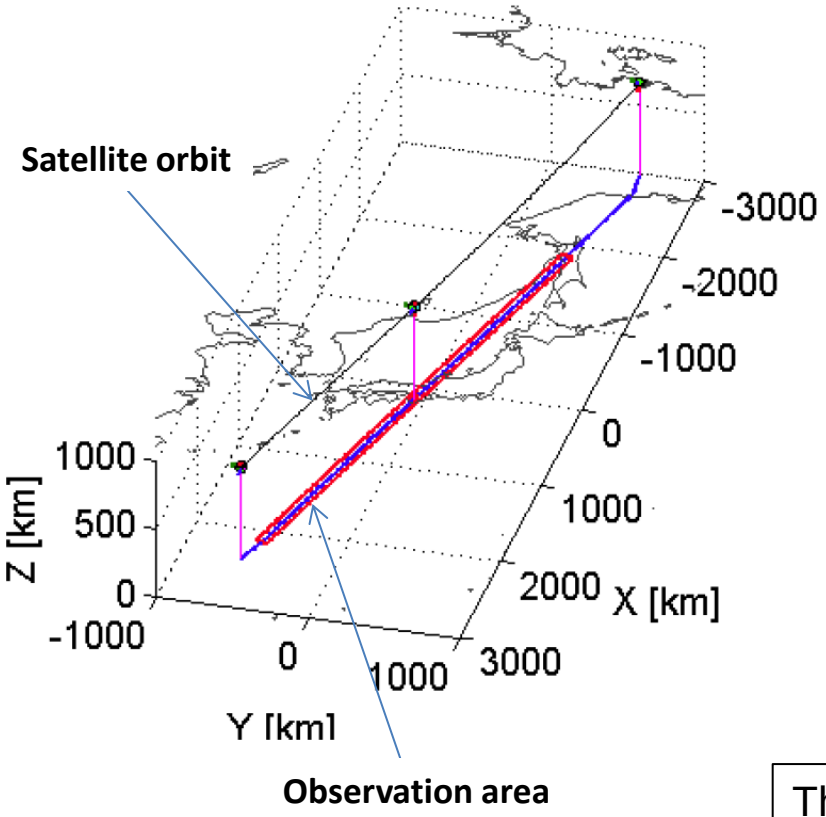


Observation Modes

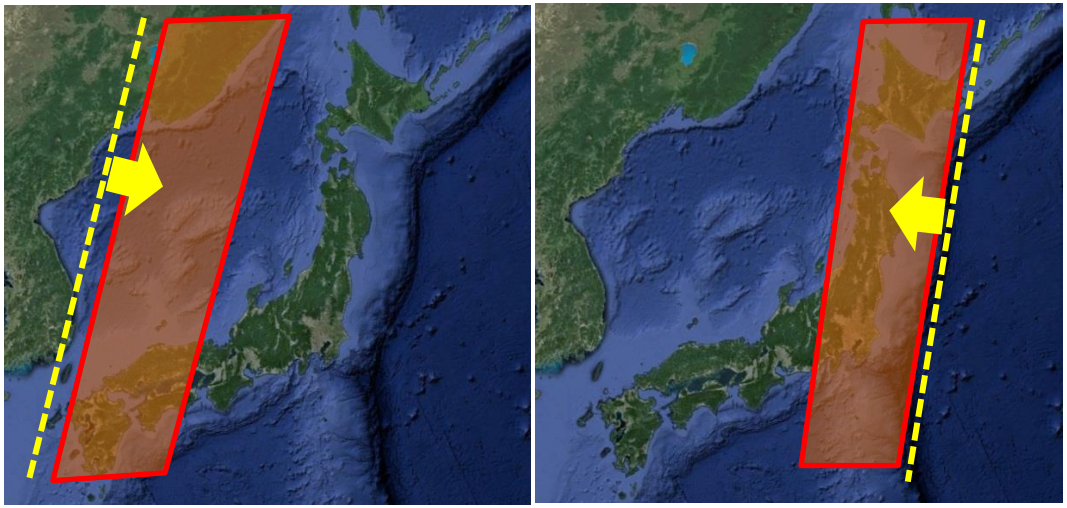
1	**Strip-map observation**	The satellite can normally perform observation covering 70 km in width and 4,000 km in along-track direction as the strip-map observation mode. To increase the acquisition frequency, the images will be taken by less than 25 deg. pointing angle in cross-track direction (GSD < 1m) when the satellite track is in oceans.
2	**Point observation**	If the user has a certain ground point or an area of interest (AOI), the satellite can observe there using pointing capability within 60 deg. This mode will be used for natural disaster monitoring, for example.
3	**Observation direction changing**	The satellite can observe any given point by the pointing capability up to 60 deg. in all direction against the satellite nadir. In the case of Japan, it can be activated within 24 hours after receiving the request. This will be used when the large natural disaster happens e.g. the expecting Nankai Trough large earthquake.
4	**Wide-area observation**	This mode can cover in wide-ranging area of 200 km (in along-track direction) x 100 km (in cross-track direction) by satellite's single orbital passage. This will be also used when the large natural disaster happens.
5	**Stereoscopic observation**	Two ways proposes to acquire stereo-pair image: 1) in single orbit path, and 2) combining two strip-map observations by nadir view and backward view in neighboring path after three days (sub-cycle revisit orbit). The way 1) will be however not sufficient base-to-height ratio (B/H) to derive terrain information. As the advantages of the way 2), that is possible to set suitable B/H, and can acquire images over large area. However, this will depend on weather conditions i.e. cloud covers, to success stereo image acquisition within short period as a disadvantage.

1 and 5 will be used in the basic observations. 1, 3 and 5 simulated images are shown.

Strip-Map Observation Mode

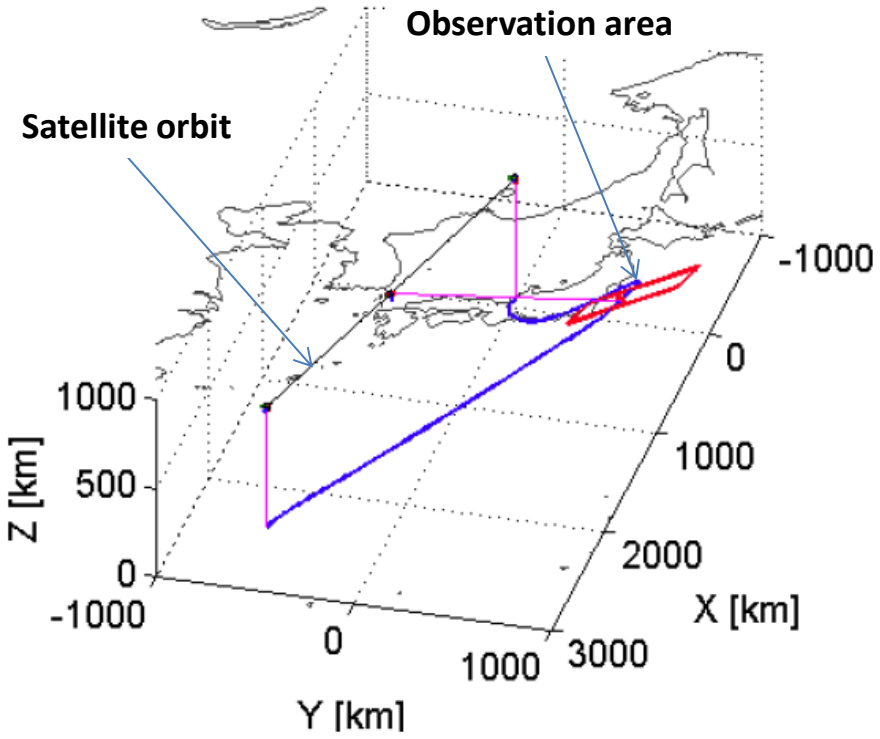


Example of nadir observation
70km x 4000km (10mins/path).

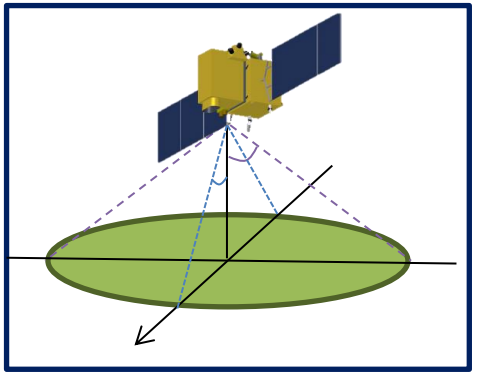


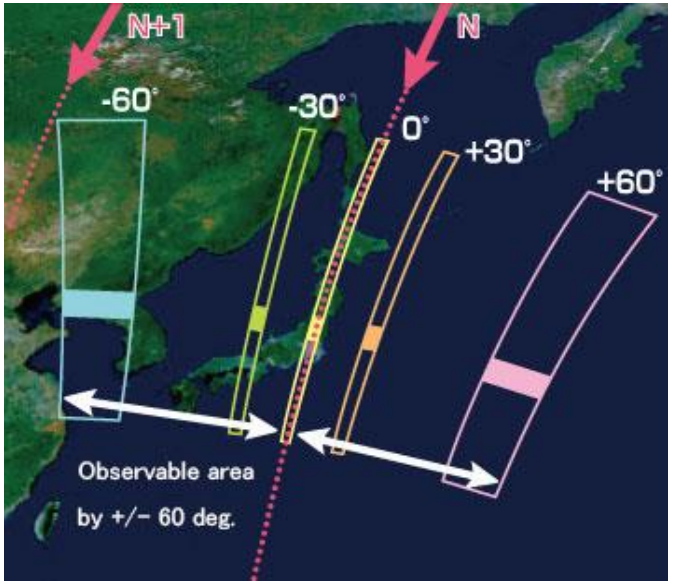
The satellite can normally perform observation covering 70 km in width and 4,000 km in along-track direction as the strip-map observation mode. To increase the acquisition frequency, the images will be taken by less than 25 deg. pointing angle in cross-track direction (GSD < 1m) when the satellite track is in oceans.

Point Observation Mode



Example of point observation by pointing function.

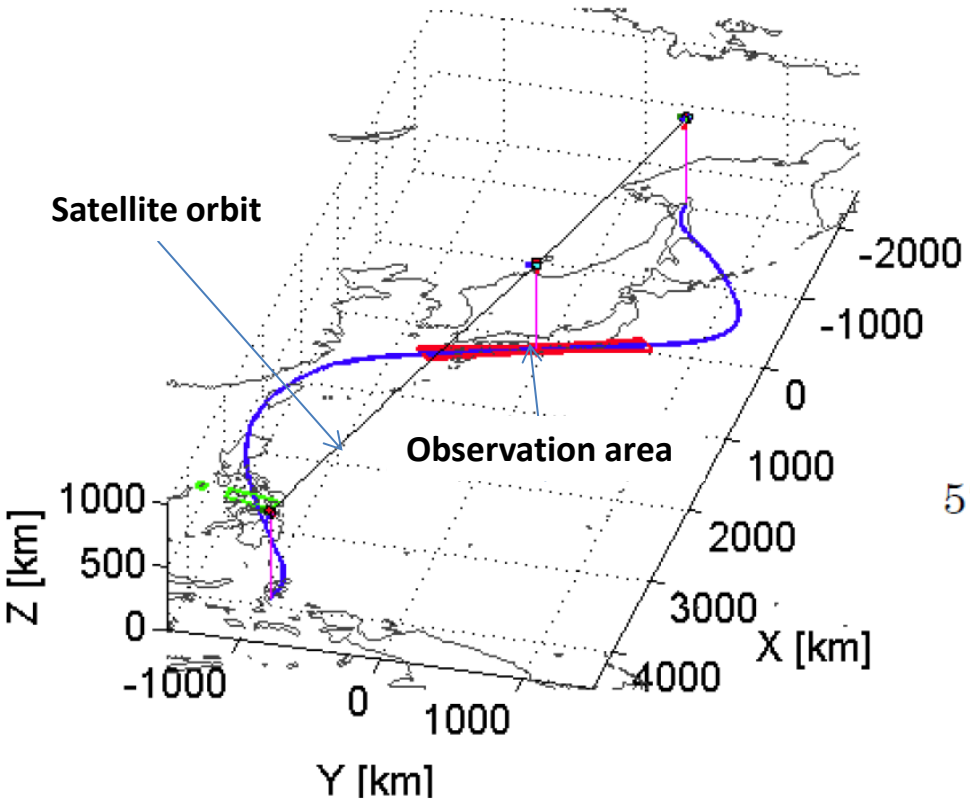


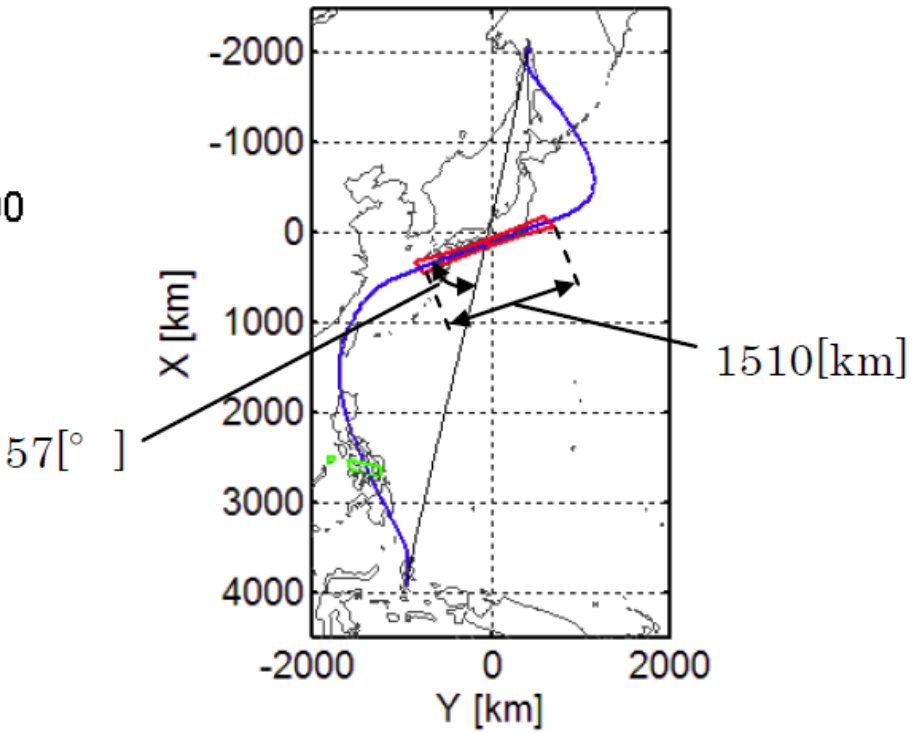


Example of coverage by +/- 60 deg. pointing function.

If the user has a certain ground point or an area of interest (AOI), the satellite can observe there using pointing capability within 60 deg. This mode will be used for natural disaster monitoring, for example.

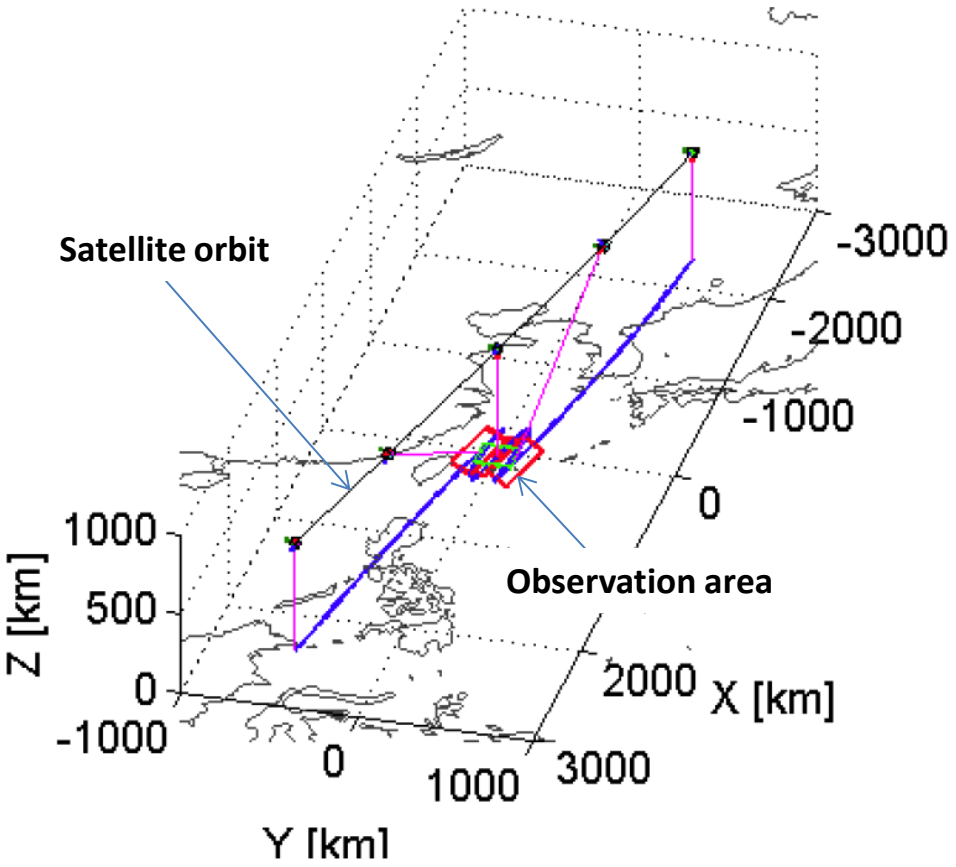
Observation Direction Changing Mode

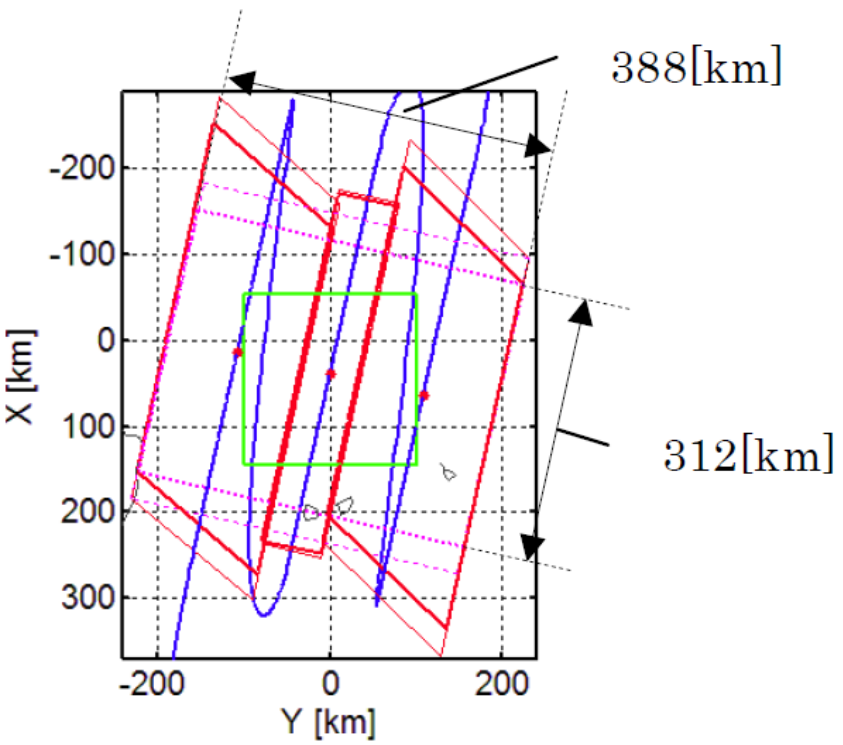




The satellite can observe any given point by the pointing capability up to 60 deg. in all direction against the satellite nadir. In the case of Japan, it can be activated within 24 hours after receiving the request. This will be used when the large natural disaster happens e.g. the expecting Nankai Trough large earthquake.

Wide-Area Observation Mode

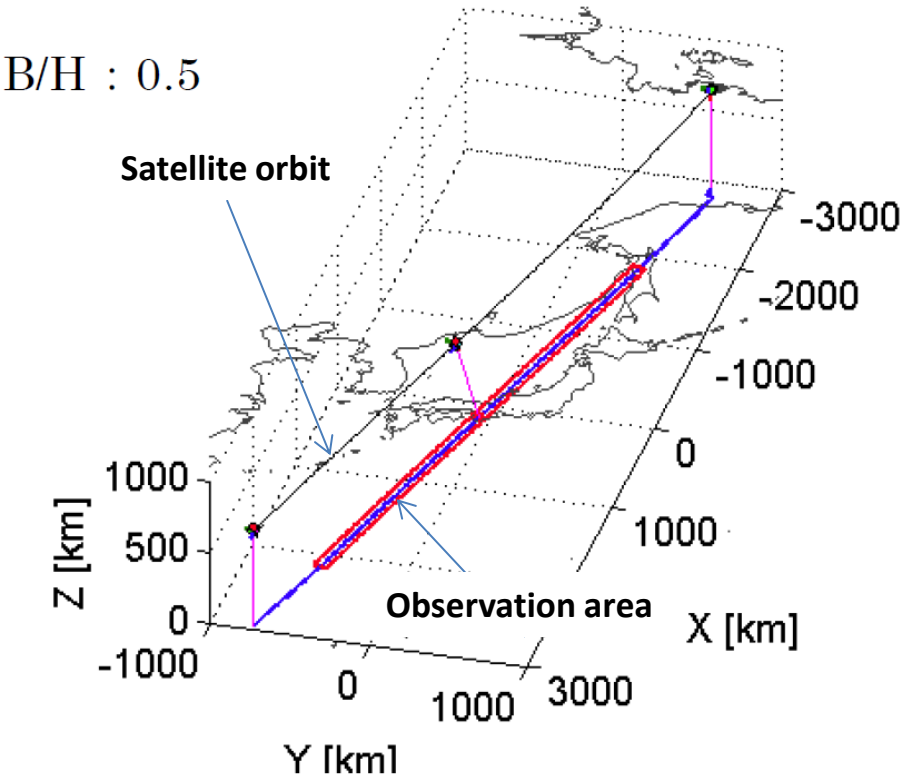




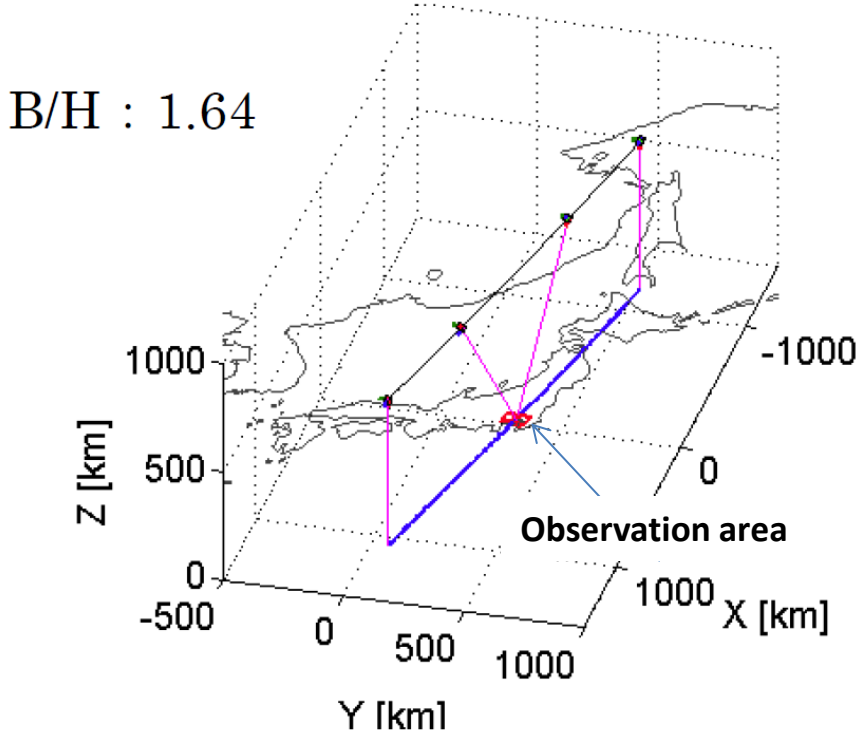
Example of three scans observation covered 388 x 312 km.

This mode can cover in wide-ranging area of 200 km (in along-track direction) x 100 km (in cross-track direction) by satellite's single orbital passage. This will be also used when the large natural disaster happens.

Stereoscopic Observation Mode



Combined two strip-map in neighboring paths after three days.



Single-path stereo.

Two ways proposes to acquire stereo-pair image: 1) in single orbit path, and 2) combining two strip-map observations by nadir view and backward view in neighboring path after three days (sub-cycle revisit orbit). The way 1) will be however not sufficient base-to-height ratio (B/H) to derive terrain information. As the advantages of the way 2), that is possible to set suitable B/H, and can acquire images over large area. However, this will depend on weather conditions i.e. cloud covers, to success stereo image acquisition within short period as a disadvantage.

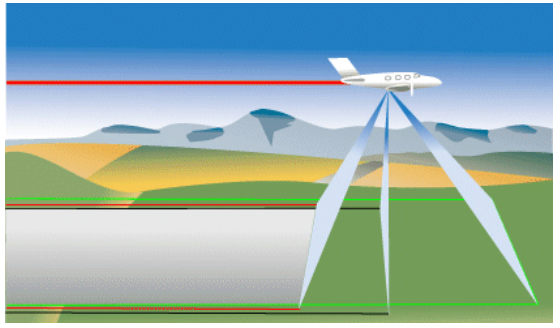
Simulated Image Generation

■ The simulated images are generated as a part of pre-launch study to consider image utilizations by users in operational phase.

- ✓ The latest or required specifications are reflected to them as much as possible, however it is impossible to create *"complete"* simulated image.
- ✓ Such limitations and conditions are clarified to use them.

■ Input data: two types of airborne images

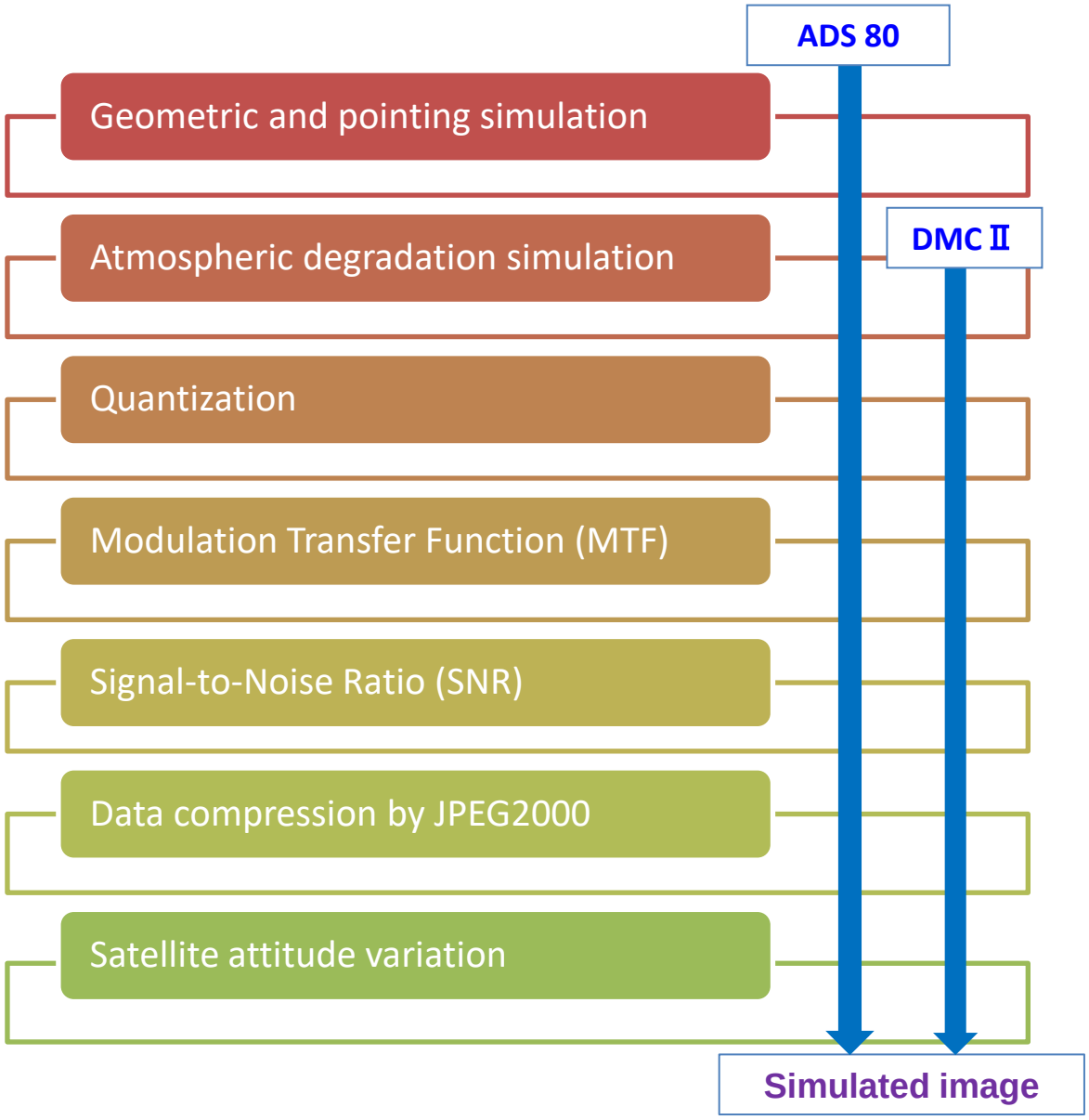
- ✓ ADS 80, Leica Geosystems AG: Three-line scanner, 20-30 cm GSD
  - – Pointing simulation
  - – *Strip-map* and *Direction Changing* modes simulation
  - – Not enough GSD



Area	Obs. date	Band	Original GSD
Tsukuba, Japan	2013/04/22	Pa/R, G, B, NIR	30 cm
Tokyo, Japan	2013/03/16	Pa/R, G, B, NIR	20 cm

- ✓ DMC II, Z/I Imaging Corp.: 8 cm GSD, only nadir image
  - – Utilization of disaster monitoring and interpretation
  - – *GSD in Strip-map* simulation
  - – Use images captured actual natural disasters:
    - » Landslide in Hiroshima, Japan; Flooding in Ibaraki, Japan

Simulated Image Generation



Processing flowchart.

Assumptions:

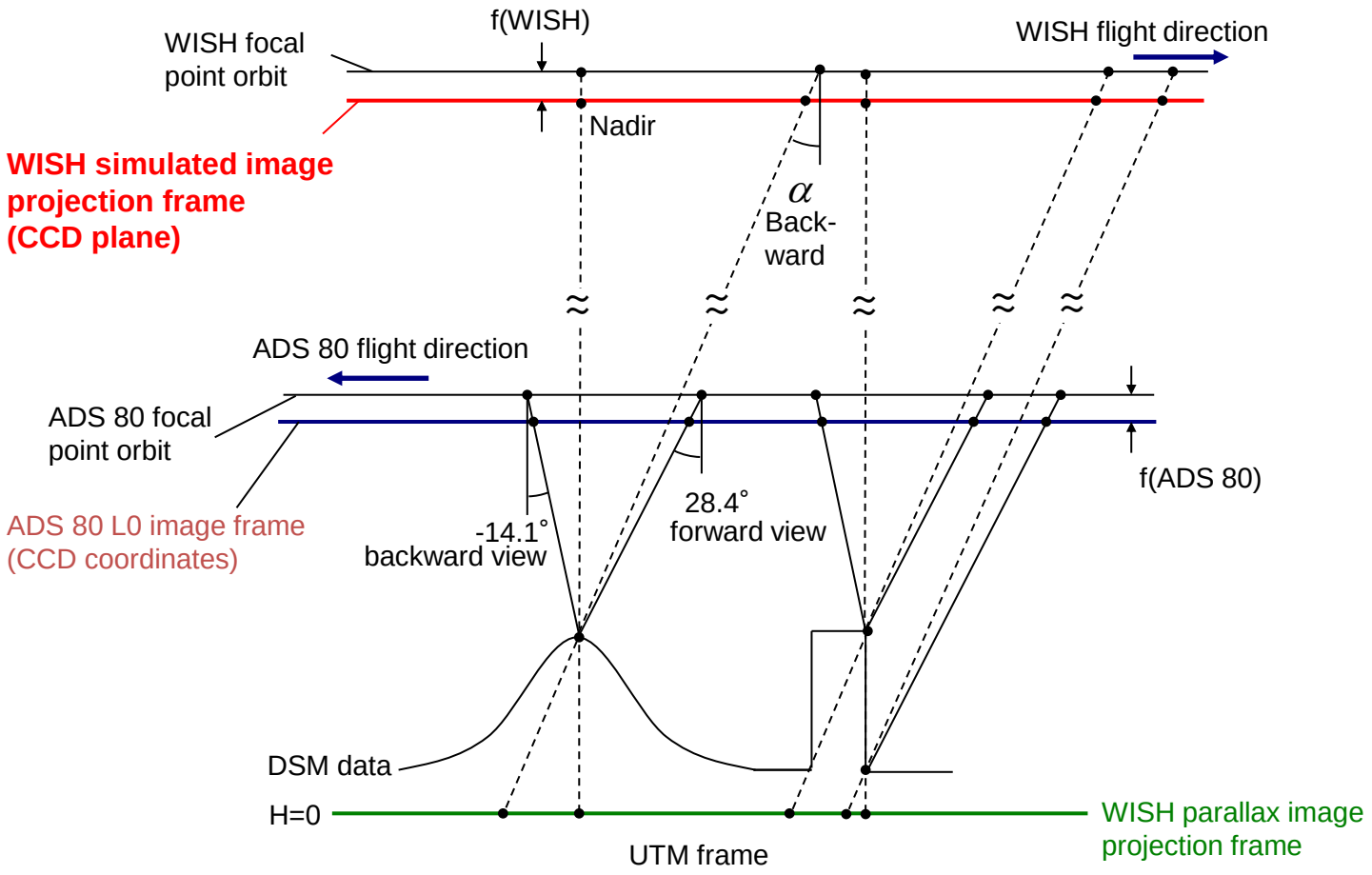
- ✓ The characteristics of input image is not affect to simulated image i.e. enough GSD, image noises and qualities.
- ✓ The simulated optics characteristics are based on the specifications.
- ✓ The onboard data compression introduces conventional JPEG 2000.

Limitations:

- Four bands for Multi available.
- Observation direction is different with the satellite.
- Target areas are limited.
- The input image characteristics sometime effected to simulated image.

Geometric and Pointing Simulation

- Geometric simulation: simulated image projection
  - Pointing: 0 for nadir; given angles for off-nadir in cross track
  - Stereo image simulation: B/H=0.5 for Backward view (BWD)



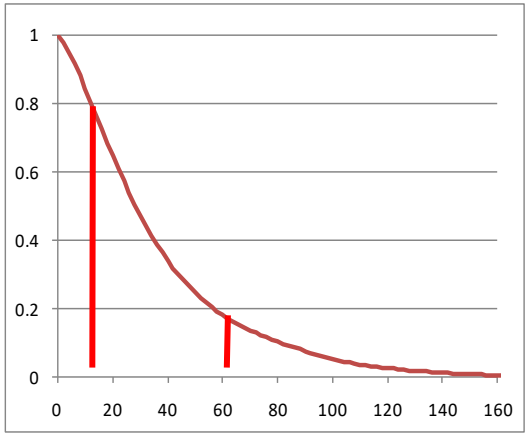
Observation and transformation geometry from ADS 80 to WISH.

Radiometric and GSD Simulation

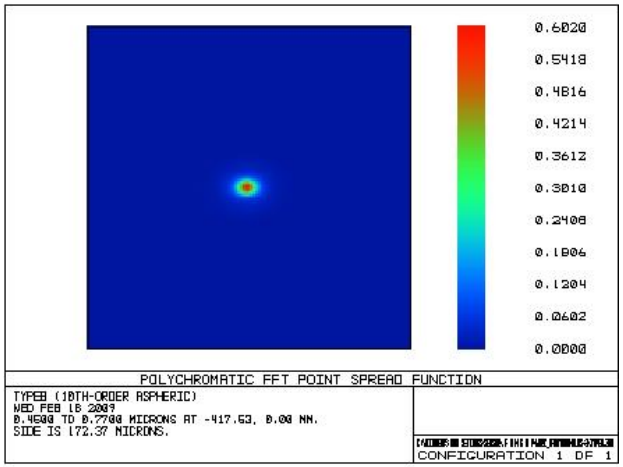
- Radiometric simulation
  - Atmospheric effects: Path radiance and diffuse transmission
  - Quantization (dynamic range): 11 bits/pixel < 16 bits/pixel of ADS 80
  - Modulation Transfer Function (MTF): convolution of the corresponding Point Spread Function (PSF) model (MTF=0.1 (Pa); 0.2 (Mu) at Nyquist), which generated by the optical design software (Zemax), than resampling to simulated GSD=0.8 m (Pa); 3.2 m (Mu)

$$MTF_{sys}(X) = MTF_{opt}(1.0) \times MTF_{det}(1.6) \times MTF_{ima.flu}(0.637)$$

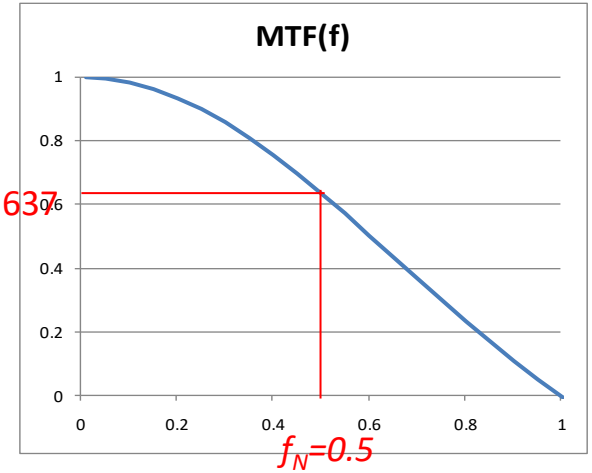
  - Signal to Noise Ratio (SNR): > 200 at 30% of max. brightness
  - Data compression: 1/4 (Pa) and 1/3 (Mu) by conventional JPEG2000



$f_{Nq(ADS\ 80))}$ $f_{Nq(WISH)}$



PSF (MTF_{det}=1.6) by Zemax



0.637

f_N=0.5

List of Simulated Images by ADS 80

■ Tsukuba, Ibaraki, Japan

	No	Contents	Roll	Pitch	Yaw	Band	File name
Strip-map	1	Nadir	0.0°	0.0°	0.0°	Pa+RGB	Tsukuba_Stripmap_000_000_PanSharpen.jpg
	2	Stereo BWD	-5.7°	-23.9°	24.43°	Pa+RGB	Tsukuba_Stripmap_057_239_PanSharpen.jpg
Direction Changing	3	AT: 750 km at center of scan (Nadir)	0.0°	0.0°	0.0°	Pa+RGB	Tsukuba_Changing_direction_000_000_PanSharpen.jpg
	4	AT: 1,125 km point, near-side	-18.9°	-12.8°	22.34°	Pa+RGB	Tsukuba_Changing_direction_189_128_PanSharpen.jpg
	5	AT: 1,125 km point, far side	-24.9°	-12.8°	27.33°	Pa+RGB	Tsukuba_Changing_direction_249_128_PanSharpen.jpg
	6	AT: 1,500 km point, near-side	-39.2°	-16.3°	40.91°	Pa+RGB	Tsukuba_Changing_direction_392_163_PanSharpen.jpg
	7	AT : 1,500 km point, far-side	-45.2°	-16.3°	46.36°	Pa+RGB	Tsukuba_Changing_direction_452_163_PanSharpen.jpg

■ Shibaura, Tokyo, Japan

	No	Contents	Roll	Pitch	Yaw	Band	File name
Strip-map	1	Nadir	0.0°	0.0°	0.0°	Pa+RGB	Shibaura_Stripmap_000_000_PanSharpen.jpg
	2	Stereo BWD	-5.7°	-23.9°	24.43°	Pa+RGB	Shibaura_Stripmap_057_239_PanSharpen.jpg
Direction Changing	3	AT: 750 km at center of scan (Nadir)	0.0°	0.0°	0.0°	Pa+RGB	Shibaura_Changing_direction_000_000_PanSharpen.jpg
	4	AT: 1,125 km point, near-side	-18.9°	-12.8°	22.34°	Pa+RGB	Shibaura_Changing_direction_189_128_PanSharpen.jpg
	5	AT: 1,125 km point, far-side	-24.9°	-12.8°	27.33°	Pa+RGB	Shibaura_Changing_direction_249_128_PanSharpen.jpg
	6	AT: 1,500 km point, near-side	-39.2°	-16.3°	40.91°	Pa+RGB	Shibaura_Changing_direction_392_163_PanSharpen.jpg
	7	AT: 1,500 km point, far-side	-45.2°	-16.3°	46.36°	Pa+RGB	Shibaura_Changing_direction_452_163_PanSharpen.jpg

Simulated Images by ADS 80

■ **No. 1: Tsukuba, Ibaraki, Japan**

Strip-map, Nadir

- Houses, apartment
- Small road and cars

Simulated Images by ADS 80

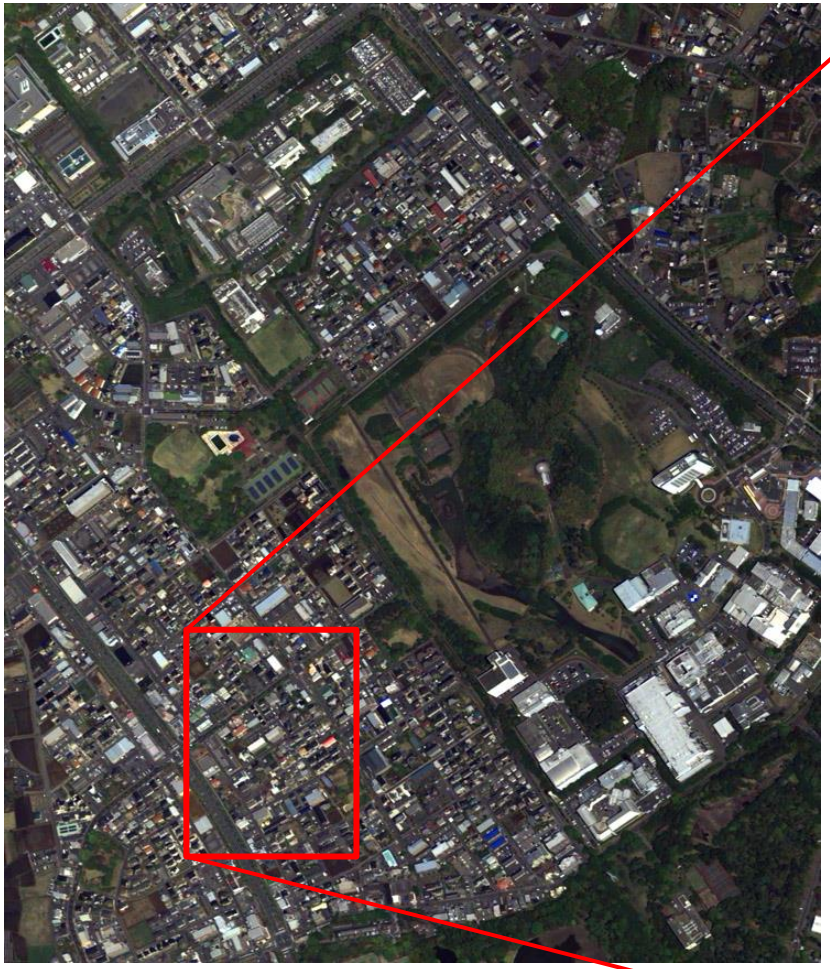
■ **No. 1: Tsukuba, Ibaraki, Japan**

Strip-map, Nadir

- Houses, apartment
- Small road and cars

Simulated Images by ADS 80

■ **No. 5: Tsukuba, Ibaraki, Japan**



Direction Changing, AT: 1,125 km, far-side

- Houses, apartment
- Small road and cars

Roll	Pitch	Yaw
-24.9°	-12.8°	27.33°

Simulated Images by ADS 80

■ **No. 7: Tsukuba, Ibaraki, Japan**

Direction Changing, AT: 1,500 km, far-side

- Houses, apartment
- Small road and cars

Roll	Pitch	Yaw
-45.2°	-16.3°	46.36°

List of Simulated Images by DMC II

■ **Landslide sites, Hiroshima Pref., Japan: Aug. 27-28, 2014**

	No	Contents	Roll	Pitch	Yaw	Band	File name
Strip-map	1	Nadir, site A	0.0°	0.0°	0.0°	Pa+RGB	HiroshimaA_Stripmap_000_000_PanSharpen.jpg
	2	Nadir, site B	0.0°	0.0°	0.0°	Pa+RGB	HiroshimaB_Stripmap_000_000_PanSharpen.jpg

■ **Flooding sites, Kinu River, Joso, Ibaraki Pref., Japan: Sep. 11, 2015**

	No	Contents	Roll	Pitch	Yaw	Band	File name
Strip-map	1	Nadir, site A	0.0°	0.0°	0.0°	Pa+RGB	KinugawaA_Stripmap_000_000_PanSharpen.jpg
	2	Nadir, site B	0.0°	0.0°	0.0°	Pa+RGB	KinugawaB_Stripmap_000_000_PanSharpen.jpg

Simulated Images by DMC II

- **Landslide sites, Hiroshima Pref., Japan: Aug. 27-28, 2014**

Strip-map, Nadir site A

Simulated Images by DMC II

- **Landslide sites, Hiroshima Pref., Japan: Aug. 27-28, 2014**

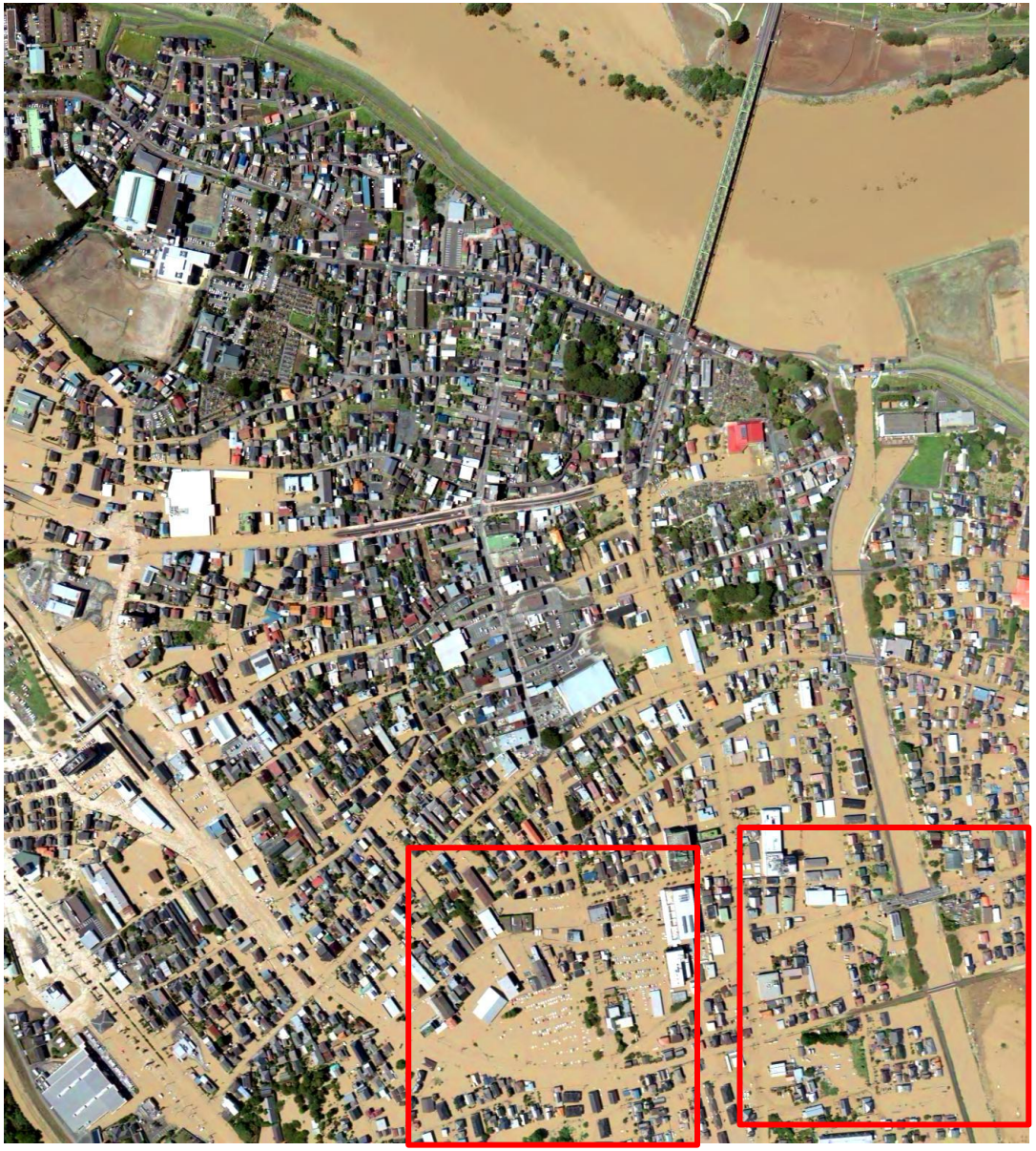
Strip-map, Nadir site B

Simulated Images by DMC II

- **Flooding sites, Kinu River, Joso, Ibaraki Pref., Japan: Sep. 11, 2015**

Simulated Images by DMC II

- **Flooding sites, Kinu River, Joso, Ibaraki Pref., Japan: Sep. 11, 2015**



Summary

- The simulated image generation was conducted that will be acquired by WISH onboard the Advanced Optical Satellite (ALOS-3), as a part of the design phase study.
- While there are some difficulties in such simulation study anytime i.e. uncertainties of specifications and characteristics for the input data, and limitation of acquisitions, it is important to obtain satisfied data and to achieve the mission objectives after the launch.
- We are asking to users their potential utilizations.
- The simulated image will be updated based on the latest design information as the pre-flight study by launching the satellite.